

REPORT

ON THE

Petroleum Indications

AT CHEVERIE,

HANTS COUNTY, NOVA-SCOTIA.

In Reference to the Probability of a Permanent Supply being
Reached by Boring.

BY

HENRY Y. HIND, M. A.

(Geologist to the Canadian Red River Expedition of 1857.—In charge of the Assiniboine and Saskatchewan Expedition of 1858.—Author of Narrative of the Canadian Expeditions to the North West.—Explorations in the Interior of the Labrador Peninsula.—Report on the Geology of New Brunswick, &c.—Reports on Waverley and Sherbrooke Gold Districts, &c.)

WINDSOR, N. S., C. E. DEWOLFE :

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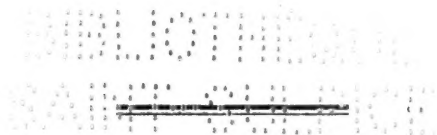
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Report on the Petroleum Indications

AT CHEVERIE.

I.—INTRODUCTION.

There are certain guides and conditions which should govern explorations for petroleum. Feeble external indications are not generally sufficient of themselves to warrant an immediate expenditure of capital, especially in a region where natural petroleum springs are not known to exist at the present time. A knowledge of the geological structure of the country, the age and character of the rocks, and especially the disposition of the strata, are all essential in endeavouring to form an opinion of the chances of success or failure in a search for oil. Hence, before describing the results of a recent examination at Cheverie, it will be advisable to sketch briefly—

- 1st.—The Geological Relations of Petroleum ;
- 2nd.—The Indications of the Presence of Oil in Underlying Strata ;
- 3rd.—The Supposed Origin of Petroleum ;
- 4th.—The Conditions Required to Render a Flow of Oil Probable.

It may appear unnecessary to enter into these details in a Report on a single locality in Nova Scotia, but it must be borne in mind that the occurrence of oil in this Province in remunerative quantities is yet unknown ; that the search for it involves a considerable outlay of capital ; that its distribution and accumulation is governed by certain laws, now tolerably well known ; and, that if found in quantity, it instantly becomes a source of wealth to the explorers, and may soon become a very important item in the mineral productions of the Province.

Five years after the discovery of Petroleum in the United

States (for commercial purposes), the annual value of the trade rose to sixty millions of dollars, and the value of the soil in the neighbourhood of Oil Creek, that is, of a strip on each side two miles wide and twenty miles long, was estimated at \$200,000,000. Farms valued before the "oil excitement" at \$2000 have since been purchased at \$1,000,000.*

Since the first working of the Petroleum wells in the United States of America, which commenced about the year 1860, the exportation of the crude oil, or of products manufactured from it, has increased rapidly, and it now amounts to little less than one hundred million gallons a year.†

In Canada the production of crude Petroleum amounted to 2,772,224 gals. in 1869. In 1870 it rose to 9,221,088 gals. In 1869 the export amounted to 758,060 gallons, in 1870 to 5,274,068 gallons.

2.—SKETCH OF THE GEOLOGICAL RELATIONS OF PETROLEUM.

Petroleum is found in rocks of all ages, and productive wells or natural springs exist in the Silurian, Devonian, Carboniferous, Cretaceous and Tertiary Systems.

3.—OIL FROM CARBONIFEROUS ROCKS.

In West Virginia, Southern Ohio, and Eastern Kentucky, the Petroleum wells are sunk in rocks of Carboniferous age, which are the source of the oil, and the strata there are supposed to be—

1st. The Great Conglomerate Sand Rock which overlies the Lower Coal Measures.

2nd. The Lower Coal Measures themselves.

3rd. The Underlying Lower Carboniferous Limestones.

Wells sunk in these strata yield oil. Part, if not the whole‡ of these strata is supposed to be represented in Nova Scotia by the Series which extend in descending order from the uppermost beds of Plaster to the Coarse Red Conglomerate which underlies the great mass of dark-coloured Bituminous Shales called the Albert Shales. This Series is well developed over a large area in Nova Scotia and Cape Breton.

By far the larger portion of the oil produced in West Virginia and Southern Ohio, has been found along the axis of a well-marked Anticlinal fold extending from the borders of

* Draper on Petroleum : Quarterly Journal of Science, 1865.

† Nature : February, 1870.

‡ The Great Pennsylvania Conglomerate is probably represented in Eastern Canada by the Bonaventure formation. *Geology of Canada*. Report for 1860, page 239.

Southern Ohio forty miles or more into West Virginia, through Wood, Ritchie, and Wirt counties. Scarcely a barrel has been obtained in horizontal rocks, although hundreds of thousands of dollars have been expended in the search.*

The oil is contained in fissures, which in some instances have communication with the external air, thus producing either natural oil springs or gas springs. When the more volatile portions of the oil have escaped as gas, the remainder is thicker and of greater specific gravity. As the escape of gas varies from different fissures, oils of different grades are found in the same locality at different depths. As a general rule the oil found near the surface is heavy, and its specific gravity diminishes as the depth increases.

In West Virginia the oil wells ranged in 1866 from 20 feet to 400 feet in depth.†

Where there are several Anticlinal folds parallel to one another, the productive wells are always found on the axis, the intervening synclinals being barren, owing doubtless to the absence of fissures, the rocks in the *valley*, or synclinal fold, being more compressed.

Professor Andrews calls attention, in the paper before referred to, to another important class of facts in connection with the geology of Petroleum. It appears that the oils exhibit a marked tendency to accumulate in certain geological horizons. The stratigraphical position of most of the oil in Southern Ohio (in the coal measures) is in a vertical range of about 200 feet of rocks lying below the horizon of the Pomeroy coal seam.

On Big Sandy River, in Kentucky, the Conglomerate below the coal is the "oil rock."

4.—OIL FROM UPPER DEVONIAN ROCKS.

In Venango county, Pennsylvania, the source of supply is chiefly fissures in the so-called third sand rock. The rock is of Upper Devonian age, and consequently underlies the oil-bearing strata previously described, which are of Carboniferous age. The third sand rock is reached at a depth of from eight hundred to a thousand feet below the coal measures. It has no known representative in Nova Scotia, and generally it may be stated that the Devonian rocks of Nova Scotia are so much altered that it does not appear probable that oil will be

* Prof. R. B. Andrews—Petroleum in its Geological Relations. Amer. Jour. of Science, July 1866.

† Ibid.

found in them, although it is not improbable that veins of Albertite and Asphaltic beds may exist. Veins of Albertite are known to occur in the altered Devonian rocks of New Brunswick.*

Professor Andrews says: "It would therefore appear to be a geological law in the Upper Devonian rocks of Western Pennsylvania that the lowest impervious sand rock retains in its fissures the oil. In the same way the hard and compact lower strata of the Waverley Sandstones of South Ohio intercept the oil as it rises from the bituminous shales below.

The Corniferous Limestone of Lower Devonian age is supposed to be the source of the oil of the Western Peninsula of Canada as shown by Dr. Sterry Hunt.† Here, as in Ohio, Pennsylvania and Kentucky, the productive wells are situated on the crowns of Anticlinals, which are all roughly parallel to one another. The same peculiarity is observed in Gaspe, where Petroleum Springs have been found on or near the crests of a number of Anticlinal folds in rocks of Devonian age. No productive borings, however, have yet been made in these rocks.

5.—INDICATIONS OF THE PRESENCE OF OIL IN UNDERLYING STRATA.

The surface indications of oil are feeble Petroleum-springs, Gas-springs, Gum-beds, saturated or impregnated strata, emitting the odour of Petroleum; small cavities containing the fluid or inspissated oil, etc.

The celebrated oil region on the Little Kanawha, Wirt county, Virginia, first attracted attention on account of the yield of oil from borings for a salt-well near the mouth of Burning Spring Brook. The only surface indications of oil in this locality are the gas-springs. In many wells the oil was entirely free from water, and passed directly from the wells into barrels for shipment.‡

In Canada, Michigan, etc., gum-beds or deposits of soft bituminous matter, frequently indicate the position of underlying sources of oil, the gum-beds being the remains of natural oil-springs after the more volatile portions of the oil have been evaporated. Similar soft bituminous deposits are found widely distributed in Gaspé and in very many parts of the United States.

* Report on the Geology of New Brunswick, by the author.

† Geology of Canada, 1863-66.

‡ E. B. Andrews—On the Geological Relations of Rock Oil. Amer. Jour. of Science, July, 1861.

On the other hand absolute reliance cannot be placed on these clues, for in some instances, owing to fractures, inclination of strata, peculiar rock-bedding and divisional planes, the source of the oil may be more or less remote, and not immediately beneath the surface indications. It is also to be observed that in some very important instances no surface indications were visible, and the finding of the oil was the result of borings for brine-springs, coal, etc., or for oil, guided by the geological structure and age of the rocks. Strata of a certain geological age, and of a particular horizon, and distinctly arranged in an Anticlinal form so that fissure receptacles may permit of the accumulation, being the only guides which led to very successful results. Far more numerous, however, are the instances where borings have been made without success in oil-bearing strata and in strata where it was not probable oil could exist.

6.—CONDITIONS REQUIRED TO RENDER A FLOW OF OIL PROBABLE.

It has been remarked by Professor Whitney that nowhere is oil obtained in large quantity where the stratum in which it originated is exposed to the air by being turned up on edge, or is only covered by light and porous accumulations of detritus. The reason of this is very evident: the oil is slowly elaborated or brought together in a certain bed or set of beds, and unless confined in some way so that it cannot escape, it must be forced to the surface by capillary attraction, hydrostatic pressure, or that of gas generated at the same time, when it escapes and is lost. To allow it to accumulate, there must be an impervious covering of rock over the oil stratum proper, which will confine the fluid within limits, and allow it to collect away from the influence of the air. For this reason a large flow of oil on the surface cannot be considered as a favourable indication for boring wells, and much less can heavy accumulations of Asphaltum (gum beds) be so regarded.

Some of the wells sunk in the Mattole Valley, Humboldt county, California, reached the depth of 1,166 feet without obtaining a flow, though sunk in a district overflowing with oil on the surface.*

Oil in a district where it is known to exist in abundance is not always obtained at once by boring; it sometimes requires many days' pumping to draw the supply to the surface. Different varieties of oil are found in the same district, which

* Prof. Browne—Mineral Resources of the U. S.

affords a strong proof of the local and independent origin of oil in adjacent regions.*

7.—SUPPOSED ORIGIN OF PETROLEUM.

Professor Lesley states that in Eastern Kentucky the plants of the Great Conglomerate have been converted into thick oil and reach the surface by horizontal drainage over the water-bearing Shales of the False or Lower Coal Measures. Below the Lower Carboniferous source of oil the next horizon is far down in the Devonian.†

Lesquereux, in a memoir on Fucoids in the Coal Formation, closes with a statement of some strong reasons for believing that Petroleum has been mainly derived from the decomposition of marine plants.‡

Dr. Sterry Hunt has alluded to the question of the origin of Petroleum in the Report of the Geological Survey of Canada for 1866. While a peculiar decomposition of organic matters might give rise at once to coal and marsh gas, a different transformation of the same matter might yield petroleum.

Dr. Newberry and others have supposed Petroleum to be the product of a slow distillation of bituminous strata. This view suggests another enquiry of equal importance, namely, the origin of the bitumen.

8.—AGE OF THE ROCKS OF CHEVERIE.

The strata at Cheverie form part of an immense deposit of Lower Carboniferous rocks which cover many hundred square miles in the Basin of the Bay of Fundy.

These rocks consist in ascending order of:—

1. Beds of Conglomerate, resting on Devonian or Silurian Strata.
2. Beds of Grit and Sandstone.
3. A deposit of dark coloured Shales of great thickness, containing an extraordinary profusion of fish remains and marine plants with thin limestone beds.
4. Beds of Sandstone and Conglomerate.
5. Beds of Marl and Shale.
6. Beds of Sandstone, Grit and Marly Shales, with thin bedded Limestones.
7. Plaster.

As already stated the age of the Lower Carboniferous rocks at Cheverie is probably the equivalent of that of the Lower Carboniferous strata in Virginia which yield oil so abundantly.

* Prof. Andrews.

† Lesley—Proceedings of the American Philosophical Society, vol. x.

‡ Quoted in the American Journal of Science, Sept., 1866.

dantly. Hence, one condition favourable to the inference that oil exists in this part of Nova Scotia is satisfied.

9.—STRUCTURE OF THE ROCKS AT CHEVERIE.

The axis of a great anticlinal fold passes through Cape Split, and following a course parallel to the Coast is seen at Walton, a distance in an air line of about nine miles.

The fold has brought to the surface the great mass of black Shales which lie at or near the base of the Lower Carboniferous Series, and which are known to be very highly bituminous in some places, as well as loaded with fish and vegetable remains.

In Cheverie Bay these Shales are exposed for more than half a mile between Johnson's Creek and Cape Split, and are folded, wrinkled and disturbed in a remarkable manner. Between these Shales and the Red Sandstones and Marls south of Johnson's Creek which overlies them there is a great Fault, which appears to have a course roughly parallel to the axis of the Anticlinal and the Coast line.

South of the Fault the strata dip southerly with great regularity, and pass under the Oil Plaster of Cheverie, but come up again with a north-easterly dip *west* of the large plaster Quarry, thus showing that the plaster of Cheverie lies in the trough of a shallow, subordinate, synclinal fold nearly at right angles to the axis of the great Anticlinal, a condition which at the first blush, and under ordinary circumstances might be considered *unfavourable* for the accumulation of petroleum in the strata at Cheverie, the attitude of the beds there facilitating its escape between different layers of the inclined strata.

An examination, however, of the Coast between the large Plaster Quarry and the Oil Plaster, establishes the existence of two subordinate anticlinal folds in the trough, the distance between the inside edges of the plaster on opposite sides of the trough being 3000 feet. The axis of these folds is the same as that of the Cheverie brook, on the crown of one of which it appears to flow. Here then we have a condition *favourable* to the accumulation of oil, but not to a very large extent at or near the mouth of the Cheverie. A glance at a plan and section showing the probable position of the small anticlinals and the outcrop of the Plaster, will be enough to show that the synclinal fold in which the Plaster and Oil is found, is part of a system of low north and south Anticlinals which intersect the system of great east and west Anticlinals,

one of which has already been described as running from Cape Split to Walton.

The source of the oil in the present case is very probably the great mass of Black Shales which deeply underlie the plaster, and which appears at Cape Split and at intervals all the way to Walton, and far beyond in both directions. The heavy bedded Sandstones which overlie the Black Shales, and which contain numerous plant remains may also be one source of the oil. Under all circumstances the passages through which the accumulated oil would reach the surface, would be, 1st, between the beds of Shales, Limestone, Sandstone, Grit, Marls and Conglomerates, which constitute the Series, and as these are tilted at a greater or less angle in an anticlinal form, it is easy to see that the oil *might* have forced its way to the surface through these natural outlets, and have been thus dispersed ages since. 2nd. It might find its way to the surface through cracks, fissures and dislocations in the strata, and by such means come up anywhere in the subordinate synclinal fold. That it has done so to a large extent will be shown hereafter.

But along the lines of the subordinate Anticlinals before described, without natural fissures or dislocations existed, the oil could not reach the surface on account of the impermeable roof which the form of the Anticlinal affords. Such roof may be found in the yielding Marls which constitute a considerable portion of the strata underlying the Plaster, while the Sandstones and Conglomerate being more rigid would be fractured and fissured during the slow process of upheaval. The diagrams accompanying this report will illustrate this reasoning to the non-professional reader, and serve to show that the geological structure of the rocks is such at Cheverie as to favour the supposition that oil in considerable quantity may exist within certain limits on and near the axis or crown of the subordinate Anticlinals. On the other hand, the extremity of the North and South synclinal fold or trough in which the indications of oil are found, may justly be regarded as a gentle undulation on the flank of the great Anticlinal which passes through Cape Split and Walton, and bearing in mind the very probable local origin of Petroleum, it is reasonable to suppose that the oil elaborated in the Shales which have been exposed on and near the axis of the Great Anticlinal has disappeared ages ago, while the oil elaborated from the plant remains of the same Shales a thousand feet underneath the plaster has partially escaped through the dislocations hereafter described, but has not succeeded in making its way to the surface

between the superincumbent beds, in consequence of their compactness and the gentle undulations into which they are thrown. This view of the probability of oil underlying Cheverie at a considerable depth will be better appreciated when the remarkable indications of the former presence of oil springs in the plaster are described.

10.—EVIDENCE OF THE EXISTENCE OF OIL AT CHEVERIE.

These are decided and important. They occur in three different forms,—

- 1st. Oil in cavities in the Plaster.
- 2nd. Oil in the natural joints of the plaster rock.
- 3rd. In the form of bitumen and oil in fissures in the Plaster covering a breadth of from two to three hundred feet, and extending over an ascertained distance exceeding half a mile.

(a.) Oil in Cavities in the Plaster.

The operations at the Plaster Quarry where the oil is found have led to the removal from above the spot where the workmen are now quarrying of a mass of rock not less than 90 feet in vertical thickness. When a quantity of plaster is shattered by powder, occasionally small bubbles of a thick yellowish oil ooze out of minute crevices, and form a yellow froth of oil which gradually increases in bulk until it assumes the size of a pea to that of a small marble. Its odour resembles that of the Canadian Petroleum, and when examined with a glass it is found to be full of minute air bubbles, which cause the frothy appearance.

(b.) Oil in Natural Joints of the Plaster Rock.

The force of the powder used in blasting, detaches large masses of plaster (anhydrite) which are generally limited in one direction by natural divisional planes. The plaster quarried here is commonly known by the name of Hard Plaster or the Mineral Anhydrite. The divisional planes are frequently coated with a greenish greasy substance of buttery consistence smelling strongly of Petroleum. When exposed to the sun on a warm day, this greasy oil melts and trickles slowly off the rock when inclined. Running generally in a vertical direction, but sometimes ramifying, are numerous cavities partially lined with carbonate of lime and holding a yellowish oily substance which when exposed to warmth, melts, and has a strong odour of Petroleum. There can be no doubt, I think, that all of these substances are petroleum in a partially inspissated condition, and that the deeper the excavations are made the more fluid the oil will become.

(c.) In the form of Bitumen or inspissated oil in fissures and veins in the Plaster.

These indications extend over a breadth of three hundred feet. They consist of a vast number of parallel veins, the vein stone being chiefly Carbonate of Lime, with thin layers of bitumen and small cavities with oil, running on a course nearly due east and west, (more correctly on a course N. 75 E.) and lying wholly within the plaster. These veins appear to mark the line of a dislocation which extending through the lower rocks has so fractured the strata as to permit the oil to be brought to the surface with water holding Carbonate of Lime in solution, together with other minerals, such as fluor spar, which sometimes is found in these veins in the form of beautiful cubical crystals of a light purple or amethystine colour. The successive lines of deposition, chiefly of Carbonate of Lime, alternating with bituminous layers, show a true vein structure; and as some of these veins are from 4 to 6 inches in diameter, the length of time the fissures would require to become so filled with the calcareous mineral associated with thin layers of inspissated Petroleum as to arrest the upward flow, may afford a vague conception of the enormous quantities of Petroleum which must have escaped during by-gone ages through these crevices into the sea. Be it remembered that these veins represent ages of oil-flow, and they afford to my mind incontestible evidence of Petroleum-springs over a space three hundred feet broad and a third of a mile long, this being the space over which at intervals the band is visible with greater and less breadth, but at the so-called Oil-plaster the belt is well defined.

In addition to this line of disturbance through which the oil has escaped, there are cross veins in the plaster, nearly at right angles to the belt, and also holding vein stone with Bitumen. Specimens of these true mineral veins from the Plaster are transmitted with this report, and in some of them the Fluor-spar is plainly visible in its chrySTALLINE form.

The question now arises whether this line of fracture having provided an outlet for the Petroleum, has not also been instrumental in draining off the supply, and whether what we now see are records of exhausted deposits, or truthful indications of abundant stores still remaining in the rocks beneath?

In order to afford an answer to this very important question we must have recourse to experience in oil-producing districts.

II.—PROBABLE SOURCE OF THE OIL AT CHEVERIE.

1st. The Black shales of Cape Split and Walton, which lie near the base of the Lower Carboniferous Series are of great thickness, probably 800 to 1000 feet and more. Consequently the source from which oil may have been elaborated is ample. 2nd. The Sandstones which overlies them are similar to those beds which hold the oil in fissures in different parts of the United States: the marls which overlies the Sandstones and are intercalated with them, offer a retentive roof not liable to fracture or to be fissured except by dislocations. 3rd. Natural oil-springs exist in the Gaspé peninsula and elsewhere at a considerably greater distance from the axis of an Anticlinal than the Plaster of Cheverie is from the great Anticlinal at Cape Split. 4th. Productive wells have also been sunk at a greater distance from an Anticlinal both in the United States and Canada. 5th. The vertical depth of the Black Shales below the Plaster at Cheverie will be from 700 to 1000 feet, but the oil would very probably be found in cavities or fissures in the overlying Sandstones. Beds of dark-coloured Shale exist at a considerably less vertical distance below the Plaster than the main body of Black Shales which are loaded with fish remains and marine plants; these must be carefully distinguished from the supposed source of the oil.

12.—DIRECTIONS IN WHICH EXPLORATIONS SHOULD BE MADE.

The great line of fracture or dislocation already described naturally suggests itself as the most promising situation for exploratory wells.

The dip or underlie of the fractures and consequently of the veins holding bitumen and oil appears to trend very slightly to the south, so that a trial well near the south edge of the belt would most probably intersect the greater number of these veins, and cut off the source of supply. Again, a line nearly at right angles to the course of the bituminous veins would intersect the subordinate Anticlinals and bore-holes there would tap the oil which may have accumulated near their crests. It must be borne in mind, however, that explorations for oil, even in a well-known oil-bearing locality, are frequently unattended with success, owing to the bore-hole having failed to intersect a fissure which may exist within a few feet of its course. Hence where indications are so strong as at Cheverie, the failure of one, two, or even half a dozen bore-holes should not be considered as establishing the fact

that oil does not at present exist there, in the face of the evidences presented by indications described, and the age and structure of the strata.

13—SUMMARY.

The conclusion at which I have arrived after a careful consideration of all the facts presented at Cheverie are as follow :

1st. The age of the oil bearing strata at Cheverie, and over many hundred square miles in that part of Nova Scotia, is that of the age of the oil producing strata in West Virginia, Southern Ohio and Eastern Kentucky.

2nd. The structure of the rocks, which are thrown up in the form of a great Anticlinal is favourable to the accumulation and preservation of petroleum some distance from the axis, and especially at Cheverie along subordinate Anticlinals.

3rd. The lower strata brought to the surface by this great Anticlinal fold are of great thickness, and loaded in some parts of their development with the remains of marine plants and animals, thus supplying the material for the supposed source from which petroleum has originated.

4th. That abundant evidences exist to show that at Cheverie petroleum has during bygone ages escaped through fissures in enormous quantities, along lines of dislocation.

5th. That the existence at the present time of thick or inspissated petroleum in cavities is strong presumptive evidence that deep boring might reach stores of petroleum which have accumulated since the fissures through which it found its way to the surface in past ages were filled with true vein stone and the passages gradually closed.

6th. That exploratory bore holes can alone decide whether these stores have been exhausted at Cheverie by long continued overflow.

7th. That the evidences of the existence of petroleum at Cheverie are sufficiently strong to warrant the expenditure of capital in a systematic exploration by means of bore holes.

HENRY Y. HIND, M.A.,

Geologist,

WINDSOR, APRIL 19TH, 1871.

